Activity 5 Volcanoes and the Atmosphere

Goals

In this activity you will:

- Measure the amount of dissolved gas in a carbonated beverage.
- Understand that volcanoes emit gases such as water vapor, carbon dioxide, and sulfur dioxide.
- Describe how volcanoes are part of the hydrosphere and water cycle.
- Demonstrate awareness of how volcanoes can affect global temperatures.
- Recognize that volcanoes are part of interactive systems on Earth.

Think about It

Following the eruption of Tambora in Indonesia in 1815, snow fell in New England during each of the summer months that year!

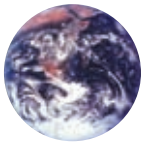
- What else escapes from a volcano besides lava, rock, and ash?

What do you think? Record your ideas about this question in your *EarthComm* notebook. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Use a can of your favorite carbonated soft drink to explore the quantity of gas that can be dissolved in a liquid under pressure.
   a) How many milliliters (mL) of liquid are in the can of soda?
   b) Predict how many milliliters of gas (carbon dioxide) a can of soda contains. Record and explain your prediction.
2. Obtain these materials: heat source, 1-liter Pyrex® beaker, water, rubber tubing (about 50 cm), smaller beaker or bottle, plastic container (shoebox size), modeling clay, safety goggles.
3. Devise a way to use the materials to measure the gas that escapes from the can of soda. Note: You will need to heat the soda after you have opened it. To do this safely, put the can in a water bath (container of water) and heat the water bath.
   a) Draw a picture of how you will set up your materials.
   b) Write down the procedures you will follow. Include the safety precautions you will take.
4. After your teacher has approved your design, set up your materials. Run your experiment.
   a) Record your results.
   b) How do your results compare to your prediction?
   c) Describe anything that might have affected your results.

Plan your activity carefully in detail to avoid potential hazards.



Reflecting on the Activity and the Challenge

You worked with a material that resembled volcanic products. When you opened the can of soda, you lowered the pressure inside the can. This allowed carbon dioxide (the dissolved gas) to come out of solution. Dissolved gases emerge from the Earth's interior in much the same way.

Digging Deeper

VOLCANOES AND THE ATMOSPHERE

Volcanic Gases

Gases that escape in greatest abundance from volcanoes are water vapor, carbon dioxide, hydrogen chloride, and nitrogen. These and certain other gases have played an important role in the Earth system throughout the long span of geologic time, and they continue to do so at the present time.

The atmosphere of the Earth early in its history contained abundant carbon dioxide but no oxygen. After primitive algae made their appearance partway through Earth history, the carbon dioxide emitted by volcanoes was gradually converted to oxygen by photosynthesis.

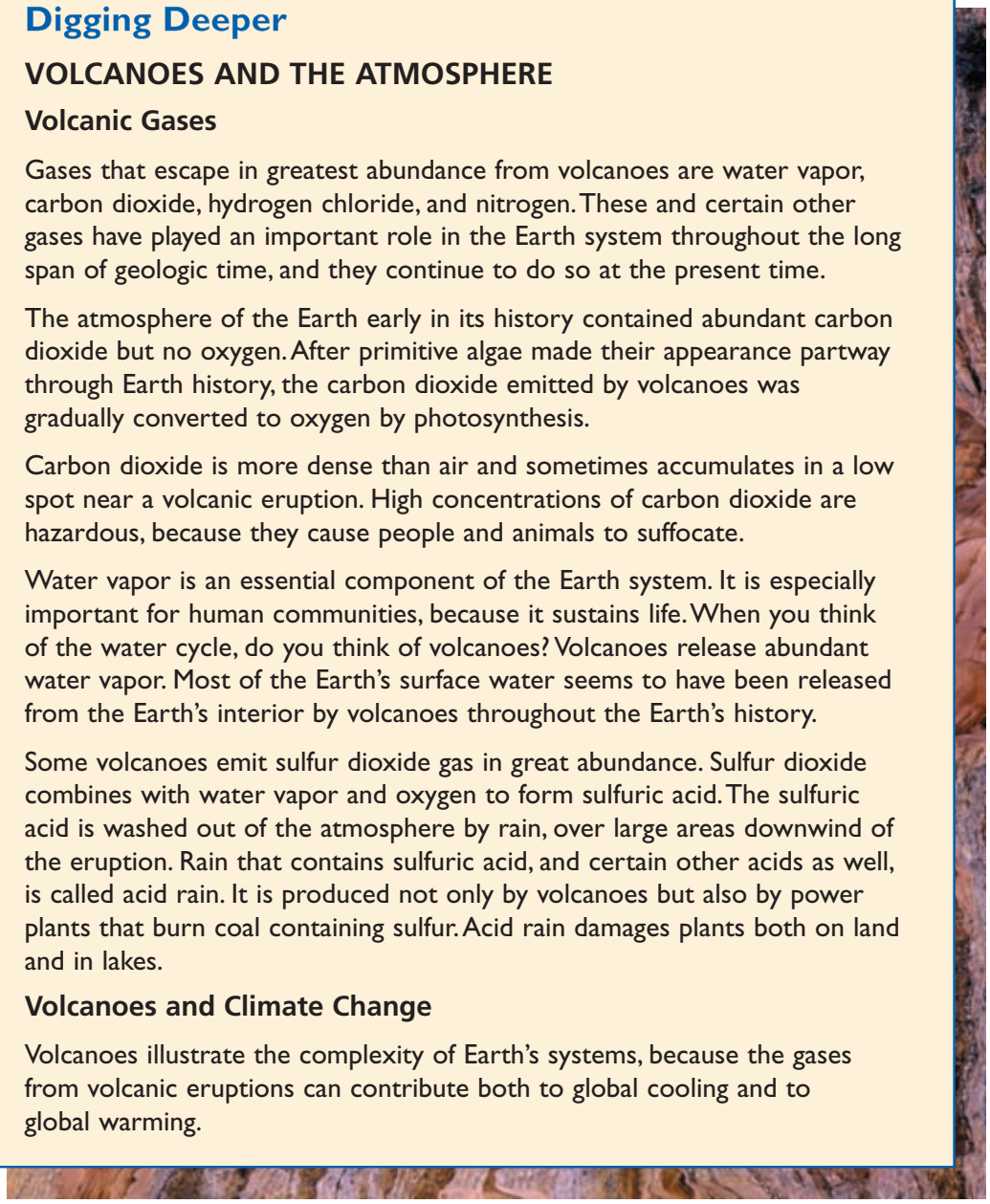
Carbon dioxide is more dense than air and sometimes accumulates in a low spot near a volcanic eruption. High concentrations of carbon dioxide are hazardous, because they cause people and animals to suffocate.

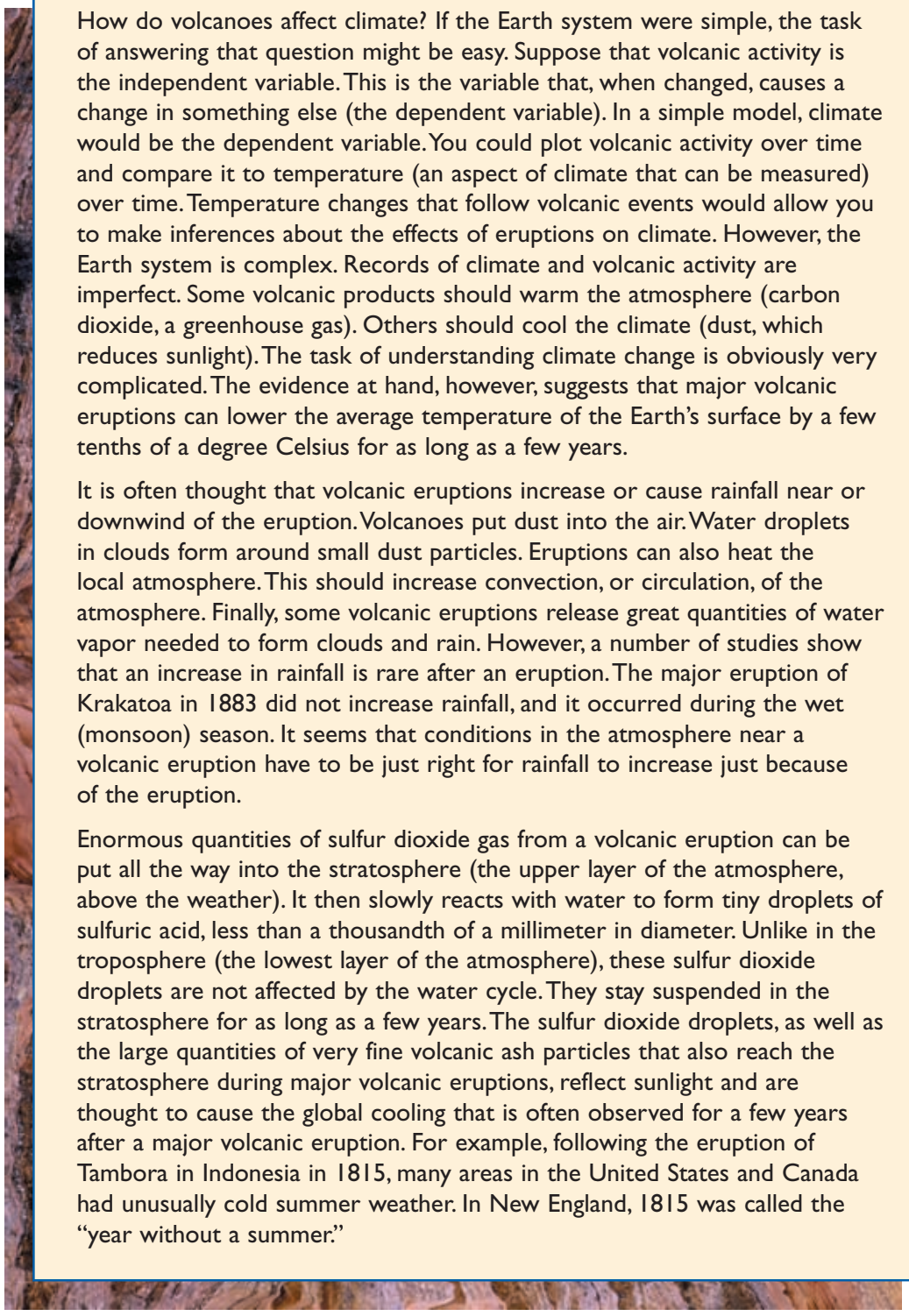
Water vapor is an essential component of the Earth system. It is especially important for human communities, because it sustains life. When you think of the water cycle, do you think of volcanoes? Volcanoes release abundant water vapor. Most of the Earth's surface water seems to have been released from the Earth's interior by volcanoes throughout the Earth's history.

Some volcanoes emit sulfur dioxide gas in great abundance. Sulfur dioxide combines with water vapor and oxygen to form sulfuric acid. The sulfuric acid is washed out of the atmosphere by rain, over large areas downwind of the eruption. Rain that contains sulfuric acid, and certain other acids as well, is called acid rain. It is produced not only by volcanoes but also by power plants that burn coal containing sulfur. Acid rain damages plants both on land and in lakes.

Volcanoes and Climate Change

Volcanoes illustrate the complexity of Earth's systems, because the gases from volcanic eruptions can contribute both to global cooling and to global warming.





How do volcanoes affect climate? If the Earth system were simple, the task of answering that question might be easy. Suppose that volcanic activity is the independent variable. This is the variable that, when changed, causes a change in something else (the dependent variable). In a simple model, climate would be the dependent variable. You could plot volcanic activity over time and compare it to temperature (an aspect of climate that can be measured) over time. Temperature changes that follow volcanic events would allow you to make inferences about the effects of eruptions on climate. However, the Earth system is complex. Records of climate and volcanic activity are imperfect. Some volcanic products should warm the atmosphere (carbon dioxide, a greenhouse gas). Others should cool the climate (dust, which reduces sunlight). The task of understanding climate change is obviously very complicated. The evidence at hand, however, suggests that major volcanic eruptions can lower the average temperature of the Earth's surface by a few tenths of a degree Celsius for as long as a few years.

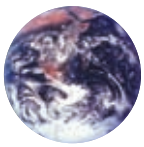
It is often thought that volcanic eruptions increase or cause rainfall near or downwind of the eruption. Volcanoes put dust into the air. Water droplets in clouds form around small dust particles. Eruptions can also heat the local atmosphere. This should increase convection, or circulation, of the atmosphere. Finally, some volcanic eruptions release great quantities of water vapor needed to form clouds and rain. However, a number of studies show that an increase in rainfall is rare after an eruption. The major eruption of Krakatoa in 1883 did not increase rainfall, and it occurred during the wet (monsoon) season. It seems that conditions in the atmosphere near a volcanic eruption have to be just right for rainfall to increase just because of the eruption.

Enormous quantities of sulfur dioxide gas from a volcanic eruption can be put all the way into the stratosphere (the upper layer of the atmosphere, above the weather). It then slowly reacts with water to form tiny droplets of sulfuric acid, less than a thousandth of a millimeter in diameter. Unlike in the troposphere (the lowest layer of the atmosphere), these sulfur dioxide droplets are not affected by the water cycle. They stay suspended in the stratosphere for as long as a few years. The sulfur dioxide droplets, as well as the large quantities of very fine volcanic ash particles that also reach the stratosphere during major volcanic eruptions, reflect sunlight and are thought to cause the global cooling that is often observed for a few years after a major volcanic eruption. For example, following the eruption of Tambora in Indonesia in 1815, many areas in the United States and Canada had unusually cold summer weather. In New England, 1815 was called the "year without a summer."

Check Your Understanding

1. What gases escape from volcanoes?
2. Why does the emission of carbon dioxide pose a threat near volcanic eruptions?
3. How are volcanoes connected to the water cycle?
4. a) How is acid rain formed?

   b) Are volcanoes the only source of acid rain?
5. Do volcanic eruptions increase or decrease the temperature of the Earth? Explain your answer.



Understanding and Applying What You Have Learned

1. Think about the air you are breathing. How much of it came from some distant volcano?
2. If a volcano erupted huge amounts of ash, would you expect global temperatures to go up or down? Why?
3. If warm air rises, why would hot gases from a volcano be a threat to people in the valley below? (Hint: think about volume's effect in your work with the lava flow lab.)
4. If a system consists of many parts that affect each other, how are volcanoes part of systems on Earth?

Preparing for the Chapter Challenge

Use the information in this activity to argue that volcanoes have affected virtually every community.

Consider ways in which you can include these arguments in your story line.

Inquiring Further

1. **Cascades eruptions**

   Examine the figure showing the eruptions of Cascade volcanoes during the last 4000 years.

   a) Which volcano has been most active? Which volcano has been least active? Explain.

   b) What three volcanoes do you think are most likely to erupt next?

   c) Visit the AGI *EarthComm* web site for a link to the USGS Cascades Volcano Observatory web site. Find out about their monitoring efforts.